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*Mulkerin Associates Inc.*



*Computer Networks & Software, Inc.*

# *Large-Scale Controller Pilot Data Link Communications (CPDLC) Emulation Testbed*

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- **Impact of data link traffic loads on the National Airspace System (NAS) communications infrastructure is not well known.**
- **FAA has established communications performance requirements for CPDLC.**
- **NASA's Glenn Research Center has developed an emulation and test facility.**
  - **Provides means of observing the operation of large-scale aeronautical data link communications using different subnetworks.**
  - **Enables study of data link interactions and capacity of NAS infrastructure to support CPDLC traffic.**

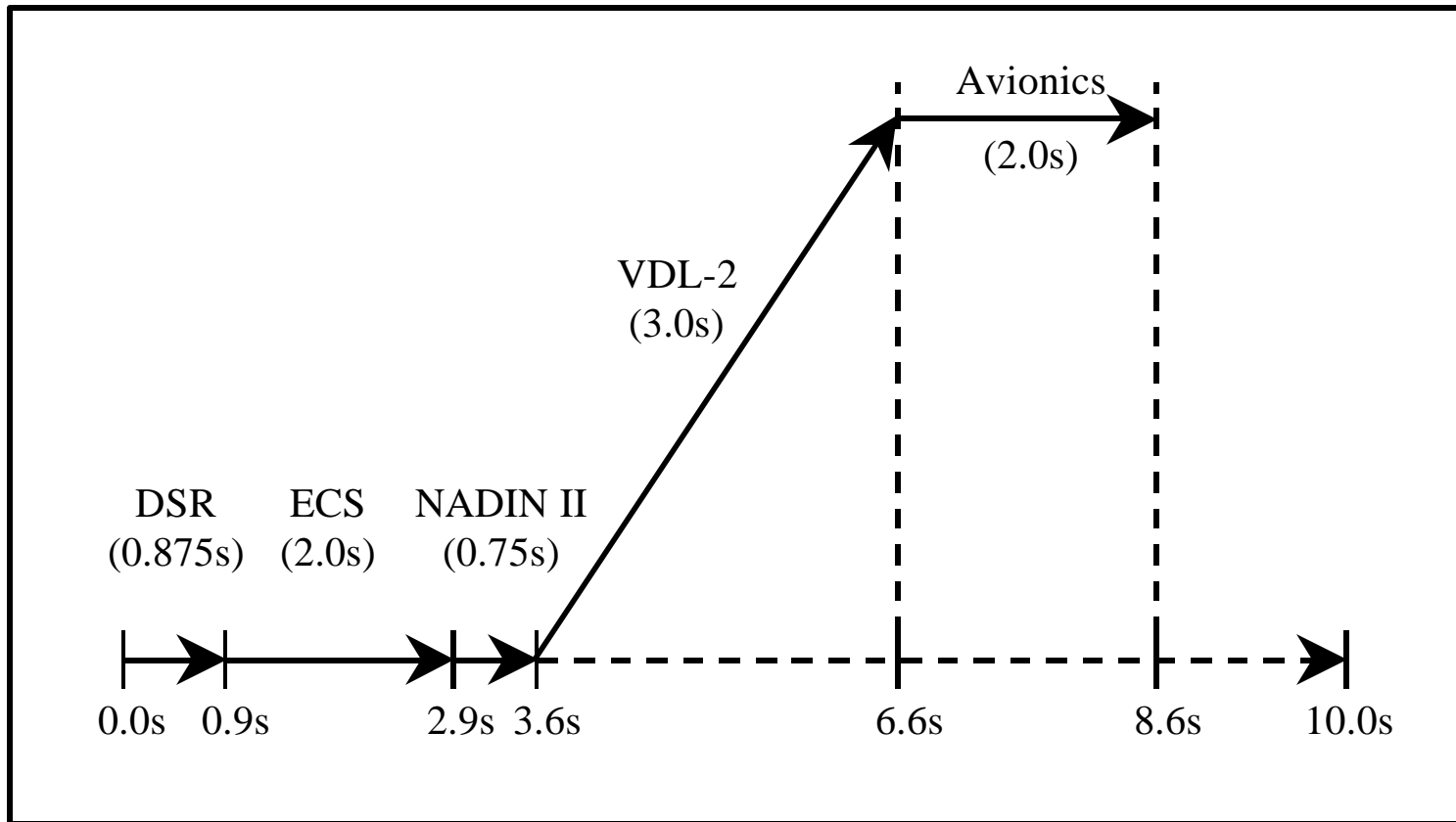
# CPDLC Performance Requirements

- FAA Requirements for End-to-End Transfer Delay**

Domain	Mean End-to-End Transfer Delay	95% End-to-End Transfer Delay	99.996% End-to-End Transfer Delay
Terminal	5 sec	8 sec	12.5 sec
En Route	10 sec	15 sec	22 sec

Source: FAA Initial Requirements Document for Controller Pilot Data Link Communications (CPDLC) Services, 22 Jun 98

- FAA CPDLC-IA Specification for En Route Delay



Mean Transfer Delay Time Budgets

- **Support realistic message traffic testing of multiple subnetworks**
  - **VDL Mode 2**
  - **VDL Mode 3**
  - **SATCOM**
  - **Others**
- **Hardware**
  - **VDL Mode 2 subnetwork**
    - » ARINC VDL Mode 2 ground station
    - » Air/ground routers
    - » Data link radios
  - **PCs for the emulation software**
  - **Local Area Network**



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## *GRC's Emulation and Test Facility*



### **Software**

- **Aeronautical Telecommunications Network (ATN) emulation software**
  - **Context Management (CM)**
  - **Controller Pilot Data Link Communications (CPDLC)**
  - **Developed by Computer Networks & Software, Inc. (CNS)**
- **ISO compliant transport and network layer protocols (TP4/CLNP)**
  - **Open Networks Engineering (ONE) OSI Foundation v 4.46**
- **Windows NT OS**





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# *Large-Scale CPDLC Emulation*

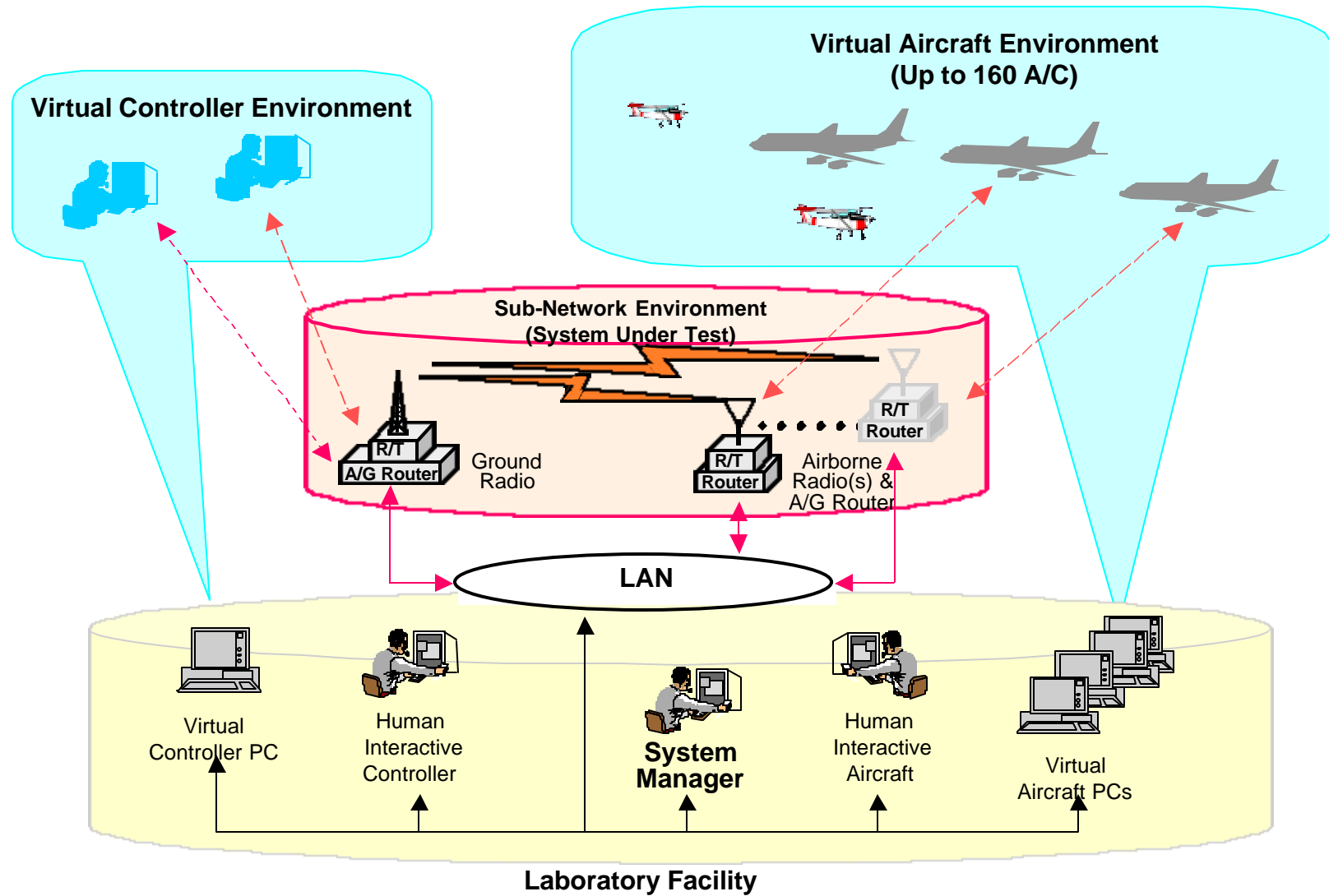


## **Distributed ATN data link communications emulator**

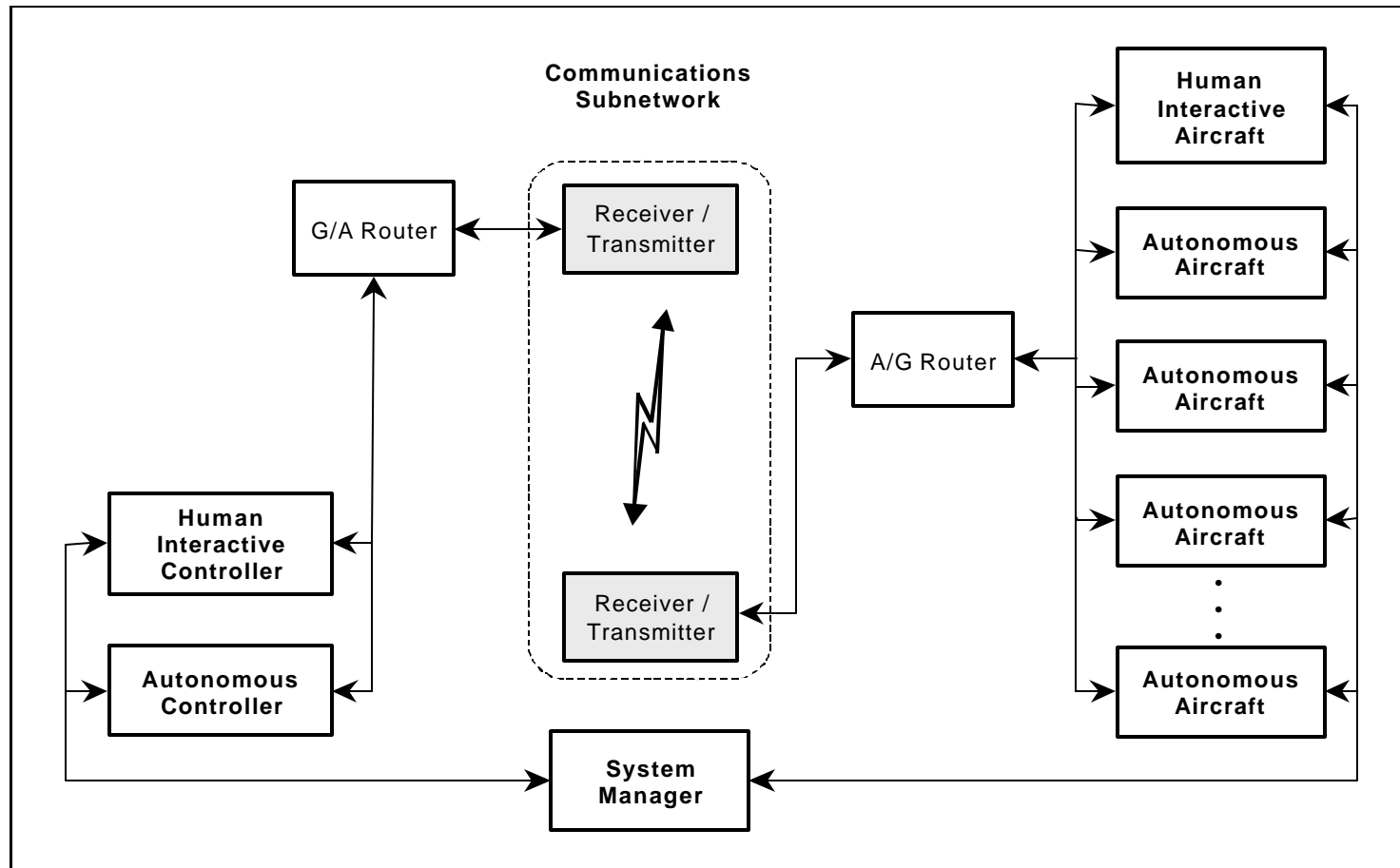
- **160+ aircraft**
- **Multiple controllers**
- **System manager: Single point of control and test data collection and reporting**
- **ATN SARPs compliant Baseline 1 CPDLC message set**
  - **105 uplink and downlink messages**



# Virtual Aircraft Emulation



# Functional Configuration



# Aircraft/Controller Functionality

## GUIs

- Emulates Generic ATC Workstation
- Emulates Generic MCDU
- Message Alerting & Display
- Message Selection & Composition
- Actions Taken Indicators
- “Free Play” CPDLC with ATSP
- Controller Display has Full Data Blocks

## Human Interactive Aircraft & Controller

- “Human in the Loop” Testing
  - User Configuration, Initialization and Experiment
  - Responses Based on Received Message
- Monitored by System Manager
- Communications:
  - ATN Compliant (TP4/CLNP)
  - Between Interactive Controller and Aircraft via ATN Subnetwork
  - With System Manager
- Automatically Saves all Configuration and Experiment Data

## CM Services

- CM Logon
- CM End
- CM Abort

## CPDLC Services

- CPDLC Start Request
- CPDLC Message Service
- CPDLC End Service Request

## CPDLC Messages

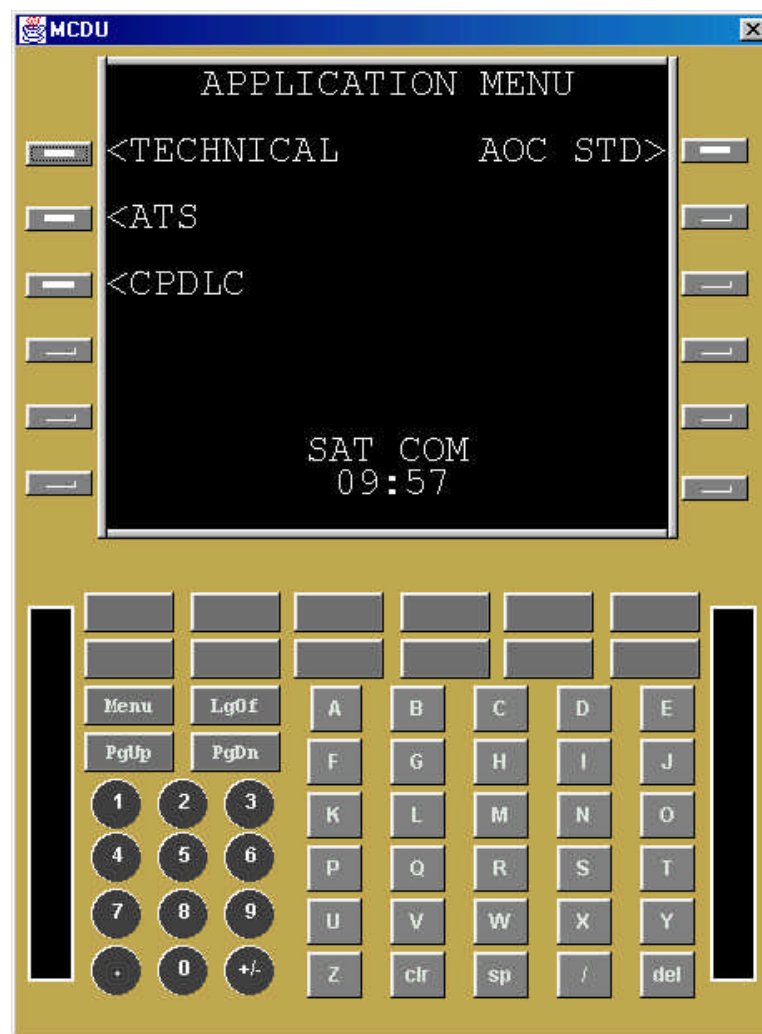
- SARPs Compliant CPDLC
  - 69 Uplink Messages
  - 36 Downlink Messages
- ADLS Baseline 1 Message Set
- Message Element Concatenation

## Autonomous Aircraft & Controller

- Up to 160 Aircraft Emulated
- Script Driven
  - Timed Aircraft Requests
  - Timed Controller Instructions
  - Automated Response to Requests based on Received Message
- Managed, Controlled and Monitored by System Manager
- Communications:
  - ATN Compliant (TP4/CLNP)
  - Between Aircraft and Controller via ATN Subnetwork
  - With System Manager
- Automatically Saves all Configuration and Experiment data



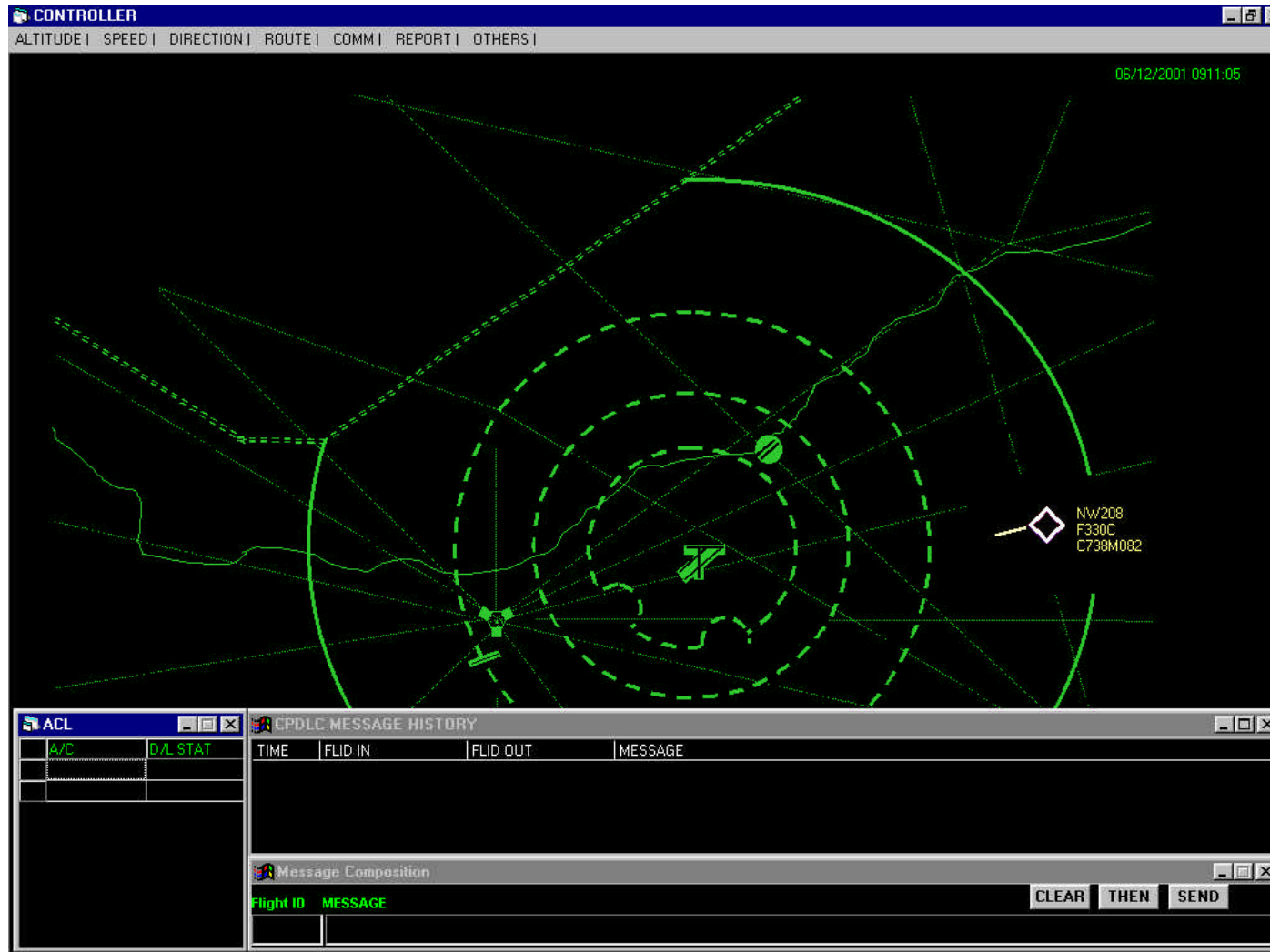
# Aircraft Display





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# En Route Controller Display



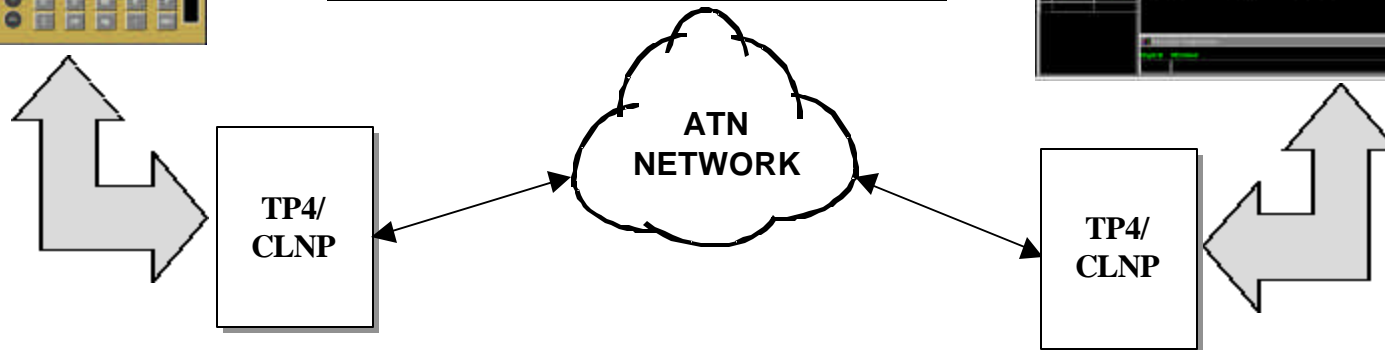
## Aircraft Display



### Features

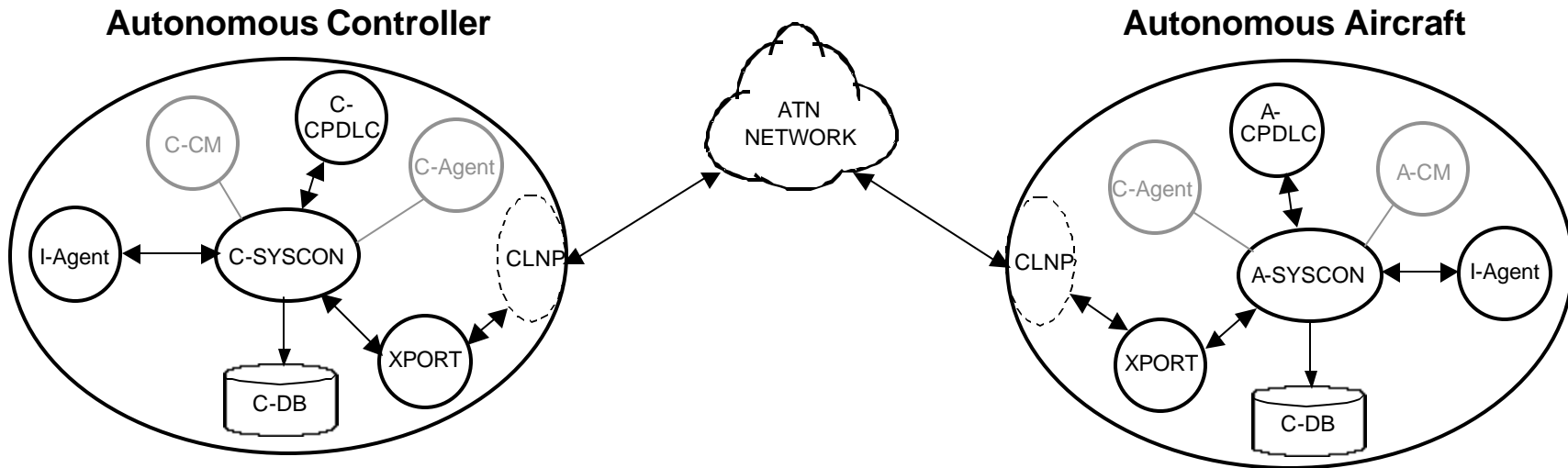
- Emulates Generic MCDU/Controller
- SARPs Compliant Baseline 1 CPDLC message set
  - 105 Messages
- Message Element Concatenation
  - 5 Message Elements
- “Free Play” CPDLC between Aircraft & Controller
- Message Alerting & Display
- Message Selection & Composition

## Enroute Controller Display

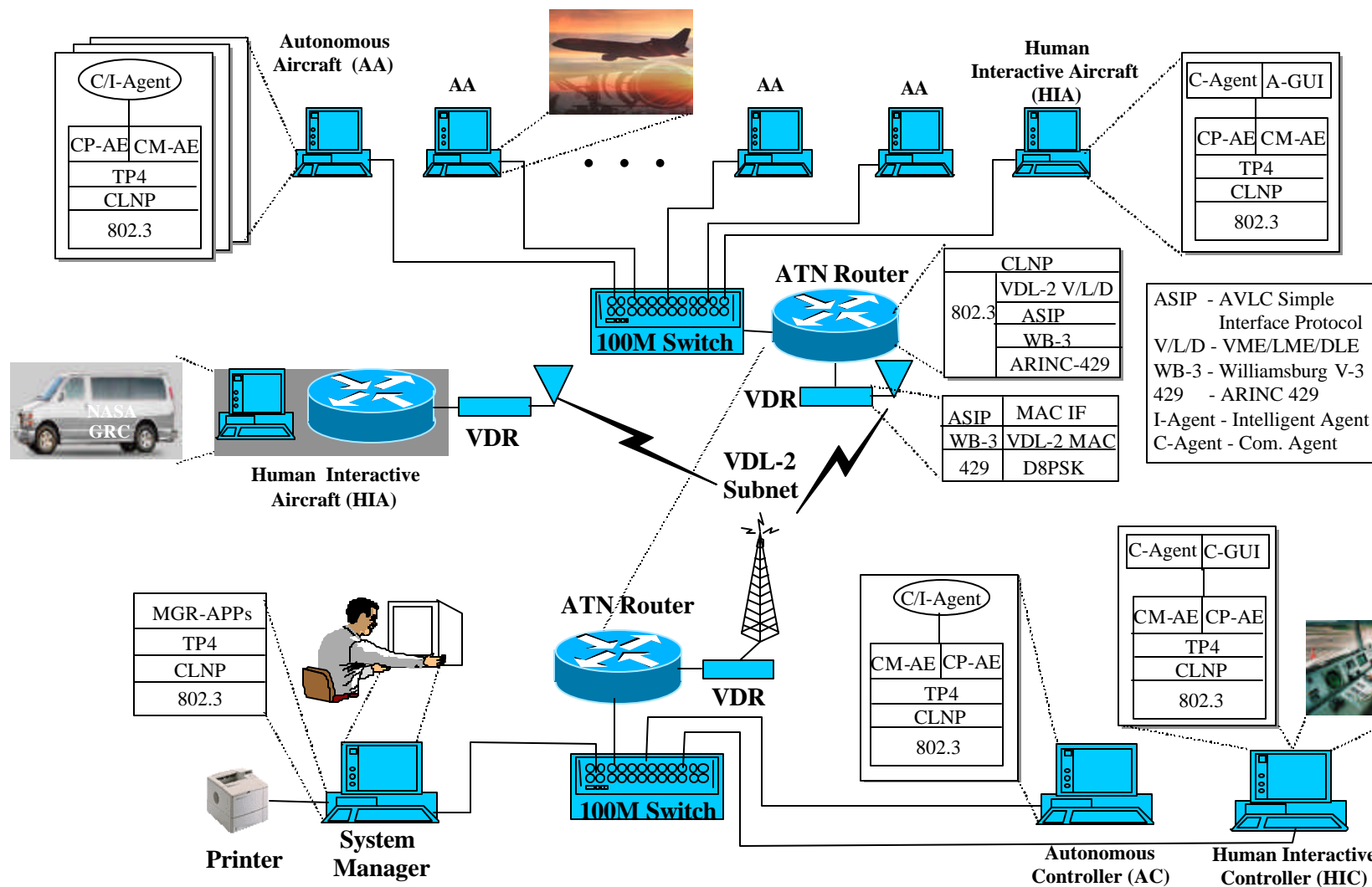


## Manual Message Input and Response

# Autonomous Message Exchange



- **Up to 160 autonomous aircraft - driven by intelligent agents**
- **Multiple autonomous controllers**
- **Automatic, script-driven aircraft/controller message exchange**
- **Responses reactive to subnetwork transport delays (“freeplay”)**
- **Experiment performance - online and offline data collection**



= System Manager Data Channel

## *Summary*

- **GRC's large-scale CPDLC emulation testbed provides the capability to study the impact of data link traffic loads on the NAS communications infrastructure.**
- **End-to-end ATN message (CM and CPDLC) emulation provides the means to assess the number of aircraft that a subnetwork can support and meet the FAA's performance goals.**



## *Contact*



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